Physics 125 Fourth Problem Set

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This covers Chapter 3.

1. Use the lorentz transformations to verify the relationship given in Lecture #6 of the notes, page 3, that
$$c^2 t_1' t_2' - x_1' x_2' = c^2 t_1 t_2 - x_1 x_2,$$
where (ct_1, x_1) are the coordinates of event #1 as viewed in the frame S, (ct_2, x_2) are the coordinates of event #2 as viewed in the same frame S, and (ct_1', x_1'), (ct_2', x_2') are the coordinates of the respective events in frame S'. The frames S and S' are related by a boost in the x direction.

2. A neutrino is incident on a neutron which is at rest. Find the minimum neutrino energy necessary to allow each of the following reactions to proceed:

   (a) $\nu + n \rightarrow e^- + p$
   (b) $\nu + n \rightarrow \mu^- + p$
   (c) $\nu + n \rightarrow \tau^- + p$

3. Proton decay has never been observed, but one of the best candidates for decay of the proton is the mode:
$$p \rightarrow e^+ \pi^0$$
Assuming the initial proton is at rest in the lab frame, determine for this mode:

   (a) The energies and magnitudes of the momenta of the e^+ and the π^0.
   (b) The energies of and the angles between the two photons from the subsequent decay $\pi^0 \rightarrow \gamma\gamma$, for one specific case. In this specific case, in the rest frame of the π^0, the two photons proceed in a direction 90° with respect to the direction of the boost that takes the π^0 back into the lab frame.

4. Griffiths 3.19.